Notice No. 3

Rules and Regulations for the
Classification of Ships,
July 2015

The status of this Rule set is amended as shown and is now to be read in conjunction with this and prior Notices. Any corrigenda included in the Notice are effective immediately.

Issue date: November 2015

Amendments to	Effective date
Part 4, Chapter 8, Sections 14 & 15	1 December 2015

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Part 4, Chapter 8

Container Ships

Effective date 1 December 2015

■ *Section 14*
Direct calculation

14.1   Procedures for calculation of combined longitudinal and torsional strength

14.1.1   For container ships ~~with a beam greater than 33 m or where the type, size and structural configuration demand, including container ships with narrow side structures, abnormal hull form or unusual structural configuration or complexity~~ as defined in 1.3.3, longitudinal strength calculations are to be made in accordance with Parts A and B of LR's ShipRight SDA for Container Ships, *see also* Table 8.14.1 Summary of direct calculation analysis requirements for container ships.

14.1.2   The global, primary and local structure scantlings are to be assessed using the vertical and horizontal wave bending moments and shear forces and torsional wave moments derived using non-linear ship motion analysis based on equivalent design sea state methods where one or more of the following conditions applies:
(a) $B > 60$ m
(b)   ~~$L > 350$ m~~ $L > 425$ m
The methodology to calculate the non-linear ship motion wave loads is given in LR's ShipRight Procedure *Guidance Notes on the Assessment of Global Design Loads of Large Container Ships and Other Ships Prone to Whipping and Springing*.

14.3   Procedures for verification of structural response due to whipping, springing and fatigue

Table 8.14.1: Summary of direct calculation analysis requirements for container ships

Rule requirement *See* Note 1	Rule reference	ShipRight notation	Application criteria. If any of the following criteria apply then the appropriate analysis is required					
			Length criteria	Any of $\lvert f_{fS} \rvert > 1{,}4$ or $RA_{BF} > 0{,}2$ or $RA_{BFU} > 0{,}2$	$f_c > f_{sp}$	Deck or hatch side coaming steel grade >= HT47	Bottom steel grade >= HT36	Breadth criteria
~~Part C of~~ LR's ShipRight SDA Procedure for container ships	~~Pt 4, Ch 8, 14.2 Procedures for verification of primary structure scantlings~~ 1.3.3	**SDA**	—	—	—	—	—	$B > 32$
~~Parts A and B of LR's ShipRight SDA Procedure for container ships~~	Pt 4, Ch 8, 14.1 Procedures for calculation of combined longitudinal and torsional strength	~~**SDA**~~	~~—~~	~~—~~	~~—~~	~~—~~	~~—~~	~~$B > 33$~~
Non-linear ship motion analysis to calculate hogging and sagging factors	Pt 4, Ch 8, 3.2 Longitudinal Strength	—	—	$L > 300$	—	—	—	—

Non-linear ship motion analysis to calculate combined vertical, horizontal and torsional loads	Pt 4, Ch 8, 14.1 Procedures for calculation of combined longitudinal and torsional strength	—	~~L > 350~~ L > 425	—	—	—	—	B > 60
Fatigue assessment	Pt 4, Ch 8, 14.3 Procedures for verification of structural response due to whipping, springing and fatigue	**FDA** (*see* Note 3)	L > 350	—	L > 250	Yes	Yes	—
Whipping assessment	Pt 4, Ch 8, 14.3 Procedures for verification of structural response due to whipping, springing and fatigue	**WDA**	L > 350	L > 300	—	Yes	Yes	—
Springing assessment *See* Note 2	Pt 4, Ch 8, 14.3 Procedures for verification of structural response due to whipping, springing and fatigue	**FDA SPR**	L > 350	—	L > 250	Yes	Yes	—

Note 1 The stated rule requirements may be deemed applicable to ships that do not meet the application criteria but where the structural configuration is such as to necessitate them.
Note 2 The results of the springing assessment may also need a fatigue assessment procedure to be undertaken.
Note 3 If ShipRight notation **FDA** is to be assigned, the requirements of LR's ShipRight FDA procedure are to be complied with; this may require calculations additional to those implied by Pt 4, Ch 8, 14.3 Procedures for verification of structural response due to whipping, springing and fatigue.

Effective date 1 December 2015

■ *Section 15*
Combined stress calculations

15.2 Symbols and definitions

15.2.1 The following symbols and definitions are applicable to this Section unless otherwise stated:
Z_Y = actual hull section modulus about the transverse neutral axis at the position considered, in m³
Z_Z = actual hull section modulus about the vertical neutral axis at the position considered, in m³
ε = shear centre distance below baseline, may be taken as the maximum shear centre distance below baseline of the ship in the midship region, in metres. ε is taken as positive where the shear centre is below the baseline
M_s = design still water bending moment at the section under consideration, in kN m (tonne-f-m)
σ_c = combined stress at the position considered.

15.3 Design loadings

15.3.1 The design vertical wave bending moments, ~~M_{WC},~~ M_{WC1} and M_{WC2}, at any position along the ship is defined as:

~~M_{WC} = $0{,}0505 C_1 L^2 B (C_b + 0{,}7) C_3$ kN m~~
~~= $(0{,}0052 C_1 L^2 B (C_b + 0{,}7) C_3$ tonne-f-m)~~

M_{WC1} = $0{,}0505 C_0 C_{31} L^2 B (C_b + 0{,}7)$ kN m
= $(0{,}0052 C_0 C_{31} L^2 B (C_b + 0{,}7)$ tonne-f-m)

M_{WC2} = $0{,}0505 C_0 C_{32} L^2 B (C_b + 0{,}7)$ kN m
= $(0{,}0052 C_0 C_{32} L^2 B (C_b + 0{,}7)$ tonne-f-m)

~~C_3 = vertical wave bending moment distribution coefficient depending on the length L_{pp} as defined in Table 8.15.1 Distribution of wave bending moments~~

C_{31}, C_{32} = vertical wave bending moment distribution coefficients depending on the longitudinal position from A.P. as defined in Table 8.15.1 Distribution of wave bending moments

~~C_1 is given in Table 4.5.1 Superstructures and deckhouses on forecastle in Pt 3, Ch 4 Longitudinal Strength.~~

C_0 = $11{,}65 \left[0{,}6 + 0{,}0942 \left(\dfrac{L}{100} - 1 \right) \right]$

L, B, C_b are given in Pt 3, Ch 1,6 Definitions.
The sign convention is given in Fig. 8.15.1 Sign conventions for hull girder loads.

15.3.2 The design horizontal wave bending moments, M_{HC1} and M_{HC2}, at any position along the ship are defined as:

~~M_{HC1} = $0{,}2063 C_1 C_{41} L^2 T (C_b + 0{,}7)$ kN m~~
~~= $(0{,}0210 C_1 C_{41} L^2 T (C_b + 0{,}7)$ tonne-f-m)~~
~~M_{HC2} = $0{,}2063 C_1 C_{42} L^2 T (C_b + 0{,}7)$ kN m~~
~~= $(0{,}0210 C_1 C_{42} L^2 T (C_b + 0{,}7)$ tonne-f-m)~~

M_{HC1} = $0{,}2063 C_0 C_{41} L^2 T (C_b + 0{,}7)$ kN m
= $(0{,}0210 C_0 C_{41} L^2 T (C_b + 0{,}7)$ tonne-f-m)

M_{HC2} = $0{,}2063 C_0 C_{42} L^2 T (C_b + 0{,}7)$ kN m
= $(0{,}0210 C_0 C_{42} L^2 T (C_b + 0{,}7)$ tonne-f-m)

C_{41}, C_{42} = horizontal wave bending moment distribution coefficients depending on the ~~length, L_{pp},~~ longitudinal position from A.P. as defined in Table 8.15.2 Distribution of horizontal wave bending moments and hydrodynamic torques

~~C_1 is given in Table 4.5.1 Superstructures in Pt 3, Ch 4 Longitudinal Strength~~

C_0 is defined in 15.3.1
L, B, T, C_b are given in Pt 3, Ch 1,6 Definitions.
The sign convention is given in Fig. 8.15.1 Sign conventions for hull girder loads.

15.3.3 The design hydrodynamic torques, M_{WTC1} and M_{WTC2}, at any position along the ship are defined as:

M_{WTC1} = $M_{WTCB1} + M_{WTCQ1}$

~~M_{WTCB1} = $0{,}0764 C_1 C_{51} L B^2 (C_b + 0{,}7)$ kN m~~
~~= $(0{,}0078 C_1 C_{51} L B^2 (C_b + 0{,}7)$ tonne-f-m)~~
~~M_{WTCQ1} = $-(0{,}65 T + f_3 \varepsilon) Q_{HC1}$ kN m (tonne-f-m)~~

M_{WTCB1} = $0{,}0728 C_0 C_{51} L B^2 (C_b + 0{,}7)$ kN m
= $(0{,}0074 C_0 C_{51} L B^2 (C_b + 0{,}7)$ tonne-f-m)

M_{WTCQ1} = $-(0{,}65 T + \varepsilon) Q_{HC1}$ kN m (tonne-f-m)

M_{WTC2} = $M_{WTCB2} + M_{WTCQ2}$

~~M_{WTCB2} = $0{,}0764 C_1 C_{52} L B^2 (C_b + 0{,}7)$ kN m~~
~~= $(0{,}0078 C_1 C_{52} L B^2 (C_b + 0{,}7)$ tonne-f-m)~~
~~M_{WTCQ2} = $-(0{,}65 T + f_3 \varepsilon) Q_{HC2}$ kN m (tonne-f-m)~~

M_{WTCB2} = $0{,}0728 C_0 C_{52} L B^2 (C_b + 0{,}7)$ kN m
= $(0{,}0074 C_0 C_{52} L B^2 (C_b + 0{,}7)$ tonne-f-m)

M_{WTCQ2} = $-(0{,}65 T + \varepsilon) Q_{HC2}$ kN m (tonne-f-m)

C_{51}, C_{52} = hydrodynamic torque distribution coefficients depending on the ~~length, L_{pp},~~ longitudinal position from A.P. as defined in Table 8.15.2 Distribution of horizontal wave bending moments and hydrodynamic torques

~~C_1 is given in Table 4.5.1 Superstructures in Pt 3, Ch 4 Longitudinal Strength~~

C_0 is defined in 15.3.1

~~f_3 = shear centre distribution factor, to be taken as:~~
~~-1,0 at the aft end of L_{pp}~~
~~1,0 between $0{,}15 L_{pp}$ and $0{,}80 L_{pp}$ from aft~~
~~-1,0 at the forward end of L_{pp}~~
~~Intermediate values are to be determined by linear interpolation:~~

~~Q_{HC1} = $0{,}8683 C_1 K_{31} L T (C_b + 0{,}7)$ kN~~
~~= $(0{,}0886 C_1 K_{31} L T (C_b + 0{,}7)$ tonne-f)~~
~~Q_{HC2} = $0{,}8683 C_1 K_{32} L T (C_b + 0{,}7)$ kN~~
~~= $(0{,}0886 C_1 K_{32} L T (C_b + 0{,}7)$ tonne-f)~~

Q_{HC1} = $0{,}8683 C_0 K_{31} L T (C_b + 0{,}7)$ kN
= $(0{,}0886 C_0 K_{31} L T (C_b + 0{,}7)$ tonne-f)

Q_{HC2} = $0{,}8683 C_0 K_{32} L T (C_b + 0{,}7)$ kN
= $(0{,}0886 C_0 K_{32} L T (C_b + 0{,}7)$ tonne-f)

K_{31}, K_{32} = horizontal wave shear force distribution coefficients depending on the ~~length, L_{pp},~~ longitudinal position from A.P. as defined in Table 8.15.2 Distribution of horizontal wave bending moments and hydrodynamic torques

L, B, T, C_b, are given in Pt 3, Ch 1,6 Definitions.

ε is given in Pt 4, Ch 8, 15.2 Symbols and definitions

The sign convention is given in Fig. 8.15.1 Sign conventions for hull girder loads.

Table 8.15.1 Distribution of wave bending moments

Position		C_3
Station	0 (A.P.)	0,000
	1	0,065
	2	0,159
	3	0,305
	4	0,464
	5	0,626
	6	0,769
	7	0,889
	8	0,966
	9	1,000
	10 (mid – L_{pp})	0,988
	11	0,919
	12	0,796
	13	0,648
	14	0,489
	15	0,344
	16	0,225
	17	0,142
	18	0,093
	19	0,060
	20 (F.P.)	0,000
Note Intermediate values are to be determined by linear interpolation.		

Table 8.15.1: Distribution of wave bending moments

Position		C_{31}	C_{32}
Station	0 (A.P.)	0,000	0,000
	1	0,062	0,018
	2	0,158	0,017
	3	0,305	-0,008
	4	0,460	-0,058
	5	0,611	-0,137
	6	0,732	-0,235
	7	0,817	-0,350
	8	0,850	-0,458
	9	0,836	-0,548
	10 (mid – L_{pp})	0,780	-0,607
	11	0,683	-0,615
	12	0,555	-0,571
	13	0,415	-0,498
	14	0,275	-0,404
	15	0,165	-0,302
	16	0,085	-0,208
	17	0,041	-0,132
	18	0,022	-0,074
	19	0,010	-0,028
	20 (F.P.)	0,000	0,000
Note Intermediate values are to be determined by linear interpolation.			

15.4 Combined stresses

15.4.2 The combined stress, σ_c, is to be ~~taken as σ_{chog}, calculated as~~ less than the permissible stress given in Table 8.15.4 Permissible stress. σ_c, is to be taken as the greatest magnitude of the following stresses:

$$\sigma_{chog} = \sqrt{(\sigma_{HC1} + \sigma_{WTC1})^2 + (\sigma_{HC2} + \sigma_{WTC2})^2} + |f_{fH} \, \sigma_{WC}| + |\sigma_{STC}| + |\sigma_{SC}|$$

$$\sigma_{C1} = \sqrt{(\sigma_1 - (1-f) \, \sigma_{WC1})^2 + (\sigma_2 - (1-f) \, \sigma_{WC2})^2} + \sigma_{SC} + |\sigma_{STC}|$$

$$\sigma_{C2} = -\sqrt{(\sigma_1 - (1-f) \, \sigma_{WC1})^2 + (\sigma_2 - (1-f) \, \sigma_{WC2})^2} + \sigma_{SC} - |\sigma_{STC}|$$

$$\sigma'_{C1} = \sqrt{(\sigma'_1 - (1-f)\,\sigma_{WC1})^2 + (\sigma'_2 - (1-f)\,\sigma_{WC2})^2} + \sigma_{SC} + |\sigma_{STC}|$$

$$\sigma'_{C2} = -\sqrt{\left(\sigma'_1 - (1-f)\,\sigma_{WC1}\right)^2 - \left(\sigma'_2 + (1-f)\,\sigma_{WC2}\right)^2} + \sigma_{SC} - |\sigma_{STC}|$$

where

$\sigma_1 = \sigma_{WC1} + \sigma_{HC1} + \sigma_{WTC1}$
$\sigma_2 = \sigma_{WC2} + \sigma_{HC2} + \sigma_{WTC2}$
$\sigma'_1 = \sigma_{WC1} - \sigma_{HC1} - \sigma_{WTC1}$
$\sigma'_2 = \sigma_{WC2} - \sigma_{HC2} - \sigma_{WTC2}$

For σ_{C1}

$f = |f_{fH}|\ \ if\ M_{WC} \geq 0,\ \ f = |f_{fS}|\ \ if\ M_{WC} < 0$

For σ_{C2}

$f = |f_{fH}|\ \ if\ M_{WC} \leq 0,\ \ f = |f_{fS}|\ \ if\ M_{WC} > 0$

where

$$M_{WC} = M_{WC1}\frac{\sigma_1}{\sqrt{\sigma_1{}^2 + \sigma_2{}^2}} + M_{WC2}\frac{\sigma_2}{\sqrt{\sigma_1{}^2 + \sigma_2{}^2}}$$

For σ'_{C1}

$f = |f_{fH}|\ \ if\ M_{WC'} \geq 0,\ \ f = |f_{fS}|\ \ if\ M_{WC'} < 0$

For σ'_{C2}

$f = |f_{fH}|\ \ if\ M_{WC'} \leq 0,\ \ f = |f_{fS}|\ \ if\ M_{WC'} > 0$

where

$$M_{WC'} = M_{WC1}\frac{\sigma'_1}{\sqrt{\sigma'_1{}^2 + \sigma'_2{}^2}} + M_{WC2}\frac{\sigma'_2}{\sqrt{\sigma'_1{}^2 + \sigma'_2{}^2}}$$

σ_{SC}	=	longitudinal stress due to hogging or sagging design still water bending moment M_s
~~σ_{WC}~~ σ_{WC1}, σ_{WC2}	=	longitudinal stress due to vertical wave bending moments
σ_{HC1}, σ_{HC2}	=	longitudinal stress due to horizontal wave bending moments
σ_{STC}	=	longitudinal warping stress due to static cargo torque
σ_{WTC1}, σ_{WTC2}	=	longitudinal warping stress due to hydrodynamic torques
f_{fH}, f_{fS}	=	hogging and sagging vertical bending moment correction factors calculated in accordance with Ch 2,2.4 Design vertical wave bending moments and 3.2.3
M_{WC1}, M_{WC2}	=	vertical bending moments defined in 15.3.1 at the longitudinal position considered

other symbols are as defined in Pt 4, Ch 8, 15.3 Design loadings and 15.4.

15.4.3   For ships with a beam greater than ~~or equal to 33~~ 32 m, longitudinal stresses are to be calculated using a finite element model of the entire hull in accordance with Part A of the LR's ShipRight SDA procedure for container ships.

15.4.4   For ships with a beam less than ~~33~~ or equal to 32 m, the longitudinal stresses may be obtained as follows:

$$\sigma_{SC}\ =\ \frac{M_s}{Z_y}\ \times 10^{-3}\ \ \text{N/mm}^2\,(\text{kgf/mm}^2)$$

$$\sigma_{wc}\ =\ \frac{M_{WC}}{Z_y}\ \times 10^{-3}\ \ \text{N/mm}^2\,(\text{kgf/mm}^2)$$

$$\sigma_{HC1}\ =\ C_7\,\frac{M_{HC1}}{Z_z}\ \times 10^{-3}\ \ \ \text{N/mm}^2\,(\text{kgf/mm}^2)$$

$$\sigma_{HC2}\ =\ C_7\,\frac{M_{HC2}}{Z_z}\ \times 10^{-3}\ \ \ \text{N/mm}^2\,(\text{kgf/mm}^2)$$

σ_{WTC1}, σ_{WTC2} and σ_{STC} are to be evaluated by approved calculation procedures.

C_7	=	coefficient for shear lag depending on vertical location of the point under consideration
	=	0,6 at inboard edge of strength deck
	=	1,0 at base line
	=	intermediate positions by interpolation

Z_y and Z_z are given in Pt 4, Ch 8, 15.2 Symbols and definitions.

15.4.6   Where the ship's length is greater than ~~350~~ 425 m or the ship's beam is greater than 60 m, the vertical wave bending moments, horizontal wave bending moments and hydrodynamic torques are to be obtained from a direct calculation method. Alternatively, the hull stresses may be obtained using a probabilistic approach response-based analysis method considering the ship's responses in wave environment. The analysis method is to be agreed with LR.

15.5 Permissible stress

Table 8.15.4: Permissible stress

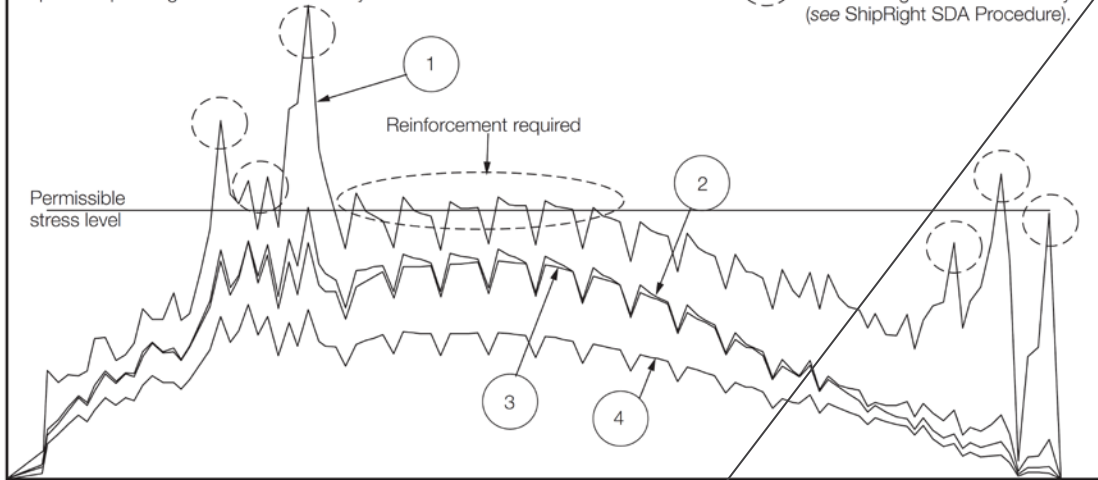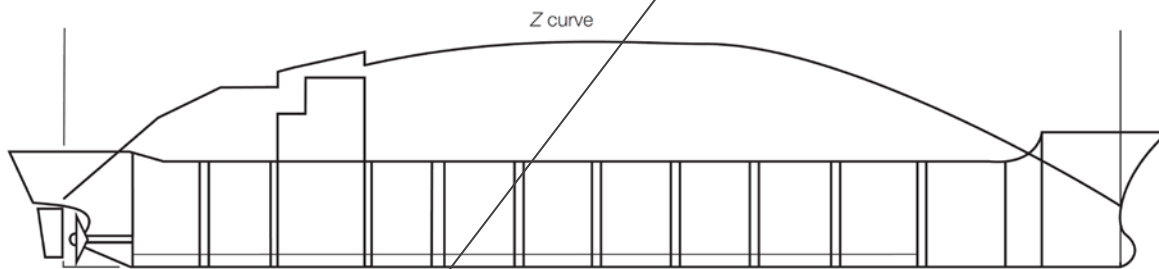| Position	Permissible combined stress, N/mm² (kgf/mm²)
Top of continuous hatch coaming	$\sigma_c = \dfrac{175}{k_L} \left(\dfrac{17,84}{k_L} \right)$
Elsewhere	$\sigma_c = \dfrac{157}{k_L} \left(\dfrac{16,0}{k_L} \right)$

Reinforcement in way of large stress peaks above the permissible stress level may be required depending on fine mesh FE analysis.
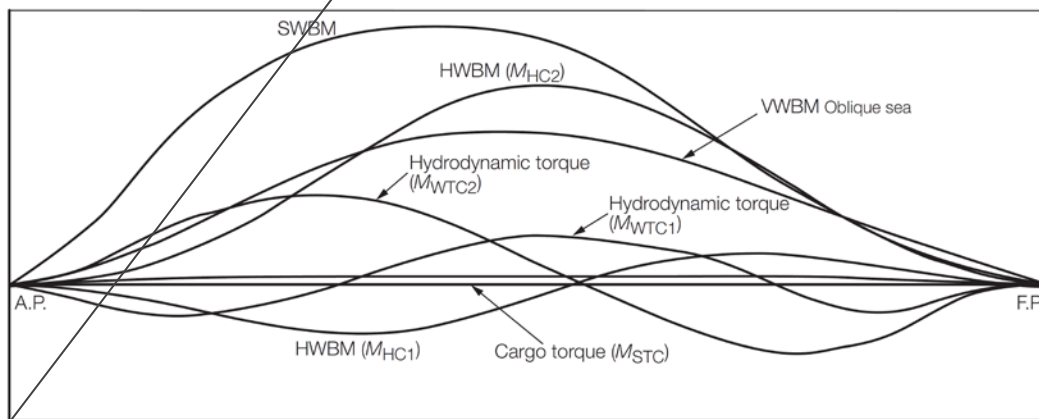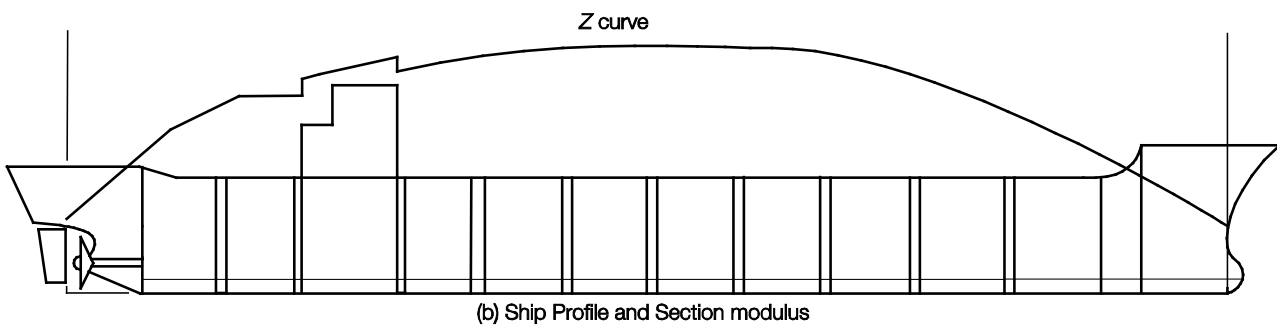
Large stress peaks identified with dotted circles are to be investigated further using fine mesh FE analysis (*see* ShipRight SDA Procedure).

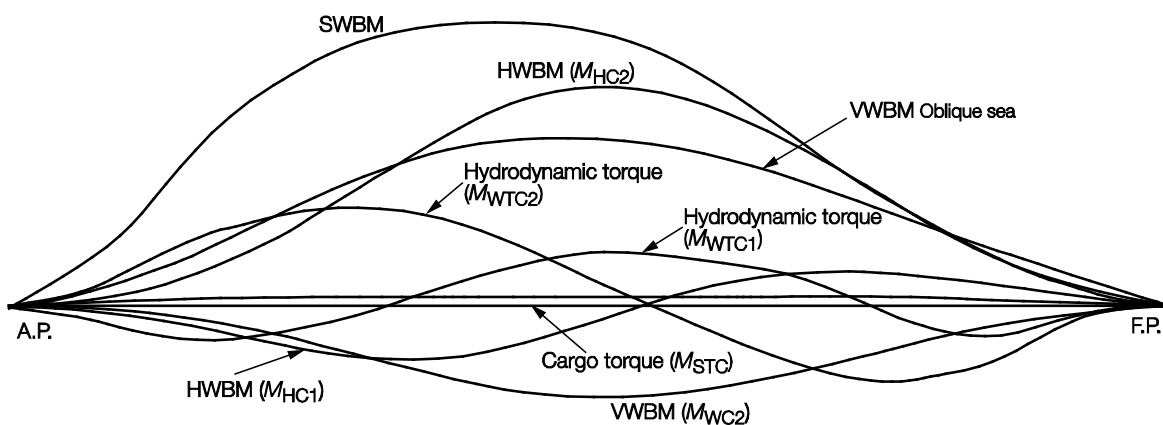Reinforcement required

Permissible stress level

1

2

3

4

(a) Longitudinal stress distributions at top of hatch coaming showing contributions from:
1) still water bending moment + vertical wave bending moment + static cargo torque + horizontal wave bending moment and hydrodynamic torque
2) still water bending moment + vertical wave bending moment + static cargo torque
3) still water bending moment + vertical wave bending moment
4) still water bending moment

Z curve

(b) Ship Profile and Section modulus

SWBM

HWBM (M_{HC2})

VWBM Oblique sea

Hydrodynamic torque (M_{WTC2})

Hydrodynamic torque (M_{WTC1})

A.P.

F.P.

HWBM (M_{HC1})

Cargo torque (M_{STC})

(c) Oblique Sea longitudinal distribution of vertical and horizontal bending moments and torques

NOTES
1. These diagrams are for illustration only and are not to scale.
2. A similar diagram is to be prepared for the bottom structure.

Fig. 8.15.2   Combined stress diagram for deck — Oblique sea

Reinforcement in way of large stress peaks above the permissible stress level may be required depending on fine mesh FE analysis.

Large stress peaks identified with dotted circles are to be investigated further using fine mesh FE analysis (*see* ShipRight SDA Procedure).

Reinforcement required

Permissible stress level

(a) Longitudinal stress distributions at top of hatch coaming showing contributions from:
1) still water bending moment + vertical wave bending moment + static cargo torque + horizontal wave bending moment and hydrodynamic torque
2) still water bending moment + vertical wave bending moment + static cargo torque
3) still water bending moment + vertical wave bending moment
4) still water bending moment

Z curve

(b) Ship Profile and Section modulus

SWBM

HWBM (M_{HC2})

VWBM Oblique sea

Hydrodynamic torque (M_{WTC2})

Hydrodynamic torque (M_{WTC1})

A.P.

F.P.

Cargo torque (M_{STC})

HWBM (M_{HC1})

VWBM (M_{WC2})

(c) Oblique Sea longitudinal distribution of vertical and horizontal bending moments and torques

NOTES
1. These diagrams are for illustration only and are not to scale.
2. A similar diagram is to be prepared for the bottom structure.

Figure 8.15.2: Combined stress diagram for deck – Oblique sea